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(57) Abstract

A method and apparatus for purifying water. The method for purifying water includes providing a cartridge having an inlet and an outlet. The cartridge is filled with at least one layer of an activated carbon and at least one layer of a mixture of ion exchange resins. The layers of activated carbon and mixed ion exchange resins may be separated by a free-floating inter-resin layer screen. A water stream is fed into the cartridge through the inlet and through the separated layers of activated carbon and mixed ion exchange resins to produce a pure water stream substantially free of organic and ionic contaminants.

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METHOD AND APPARATUS FOR PURIFYING WATER

BACKGROUND OF THE INVENTION

1. Field of the Invention:

The present invention relates to a method and apparatus for purifying water and, more particularly, to a method and apparatus for purifying water such that it is substantially free of both organic and ionic contaminants.

2. Description of the Related Art:

High purity water is required for many purposes, including use in chemical and biological analysis, production, and the like. One measurement commonly employed to determine water purity is the specific resistivity of the water in megohm-cm at 25°C, which is a measure of the ionic contamination. Pure water has a theoretical resistivity of 18.2 megohm-cm, and water can be provided approaching this value. Non-ionic contaminants such as organic materials and particulates are monitored by other analytical techniques and maximum values are sometimes specified.

Water is purified by a number of well-known techniques, including filtration, single or multiple distillation, sorption and ion exchange. Water initially treated by distillation or reverse-osmosis filtration is often further purified (or polished) by passage through activated carbon beds to absorb residual contaminant materials, principally organics. The pretreated water may also be treated by passage through layered or mixed beds of anion and cation exchange resins to remove residual ionic impurities. Often, these water streams are also filtered through microporous filters to remove residual contaminant particles.

Typically, the further purification (or polishing) of treated water streams is performed in a single multibed cartridge or in a plurality of interconnected multibed cartridges in a filter pack arrangement. For example, Pavia, in U.S. Patent No. 4,196,081, discloses an apparatus for water purification wherein one embodiment includes a single filter cartridge. The filter cartridge for purifying water includes a layer of activated carbon positioned upstream of a mixed bed of deionization resin, thereby attempting to prevent organic contamination of the resin and enhance filter efficiency. It is noted, however, that activated carbons contain ionic impurities, as well as ash (fines) that is formed from the residues of pyrolyzed spherical petroleum distillate or resin beads that are used to produce the carbons, and they occasionally collect microorganisms. All of

these contaminants can be released into the passing water. In addition, it is known that the deionization resins may release trace quantities (parts per billion) of organic contamination into the water. Although relatively minor, even this level of organic contamination can detrimentally effect organic analysis, for example, by high performance liquid chromatography, and the like.

A wide variety of water purification methods and filtration devices have been proposed to address the effect of organic and ionic impurities in water and in the carbon and resin beds. For example, a method and apparatus for producing ultrapure water is disclosed by Hedge et al., in U.S. Patent No. 4,430,226. This patent discloses a water treatment cartridge and method for producing ultrapure water substantially free of both organic and ionic contaminants, and having a resistivity of between 16 and 18 megohm-cm. The device includes a container having a particulate admixture of activated carbon and mixed bed ion exchange resins. The admixture is prepared by known techniques, including rolling the components together in a drum for a period of time. In operation, water is passed through the admixture of mixed ion exchange resins and activated carbon. In theory, the carbon removes the residual organic contamination released from the resins, and the mixed ion exchange resins remove ionic contamination released from the carbon. It has been found, however, that particulate admixtures of activated carbon and mixed bed ion exchange resins, similar to those disclosed in U.S. Patent No. 4,430,226, can separate over time as a result, in part, of the different densities and particle sizes of the admixture components, and lead to lower quality water. Moreover, preparation of the admixture prior to filling the filter cartridge may lead to production inefficiencies and handling problems.

In addition to the foregoing, it has been found that an unrestricted flow of water through a water treatment cartridge containing a particulate admixture to purify the water can create channeling in the bed along the cartridge side walls during water downflow, or fluidization of the bed during water upflow. In both instances, inefficient water contact with the admixture of activated carbon and mixed bed ion exchange resins can result in lower overall water purity. Another disadvantage associated with known filter systems, including layers or admixtures of activated carbon and mixed ion exchange resin, is the necessity of a pre-use (startup) rinse and/or a soaking time period that may last from several hours to overnight to clean the activated carbon of some ionic impurities and ash and to wet-up and expand the ion exchange resins. As a result of the required start-up procedures, it is often required to pass a water stream through the filter for a period of time to obtain high purity water.

SUMMARY OF THE INVENTION

The present invention is directed to a method and apparatus for purifying water. The present method and apparatus can produce purified water having very low organic and ionic contamination, a resistivity of greater than 17.5 megohm-cm and TOC levels less than 5 parts per billion. The method for purifying water includes providing a cartridge having an inlet and an outlet. The cartridge is filled with at least one layer of an activated carbon and at least one layer of a mixture of ion exchange resins. The layers of activated carbon and mixed ion exchange resins are separated by a free-floating inter-resin layer screen. A water stream is fed into the cartridge through the inlet and through the separated layers of activated carbon and mixed ion exchange resins to produce a pure water stream substantially free of organic and ionic contaminants. Preferably, the activated carbon layer is positioned upstream of the layer of mixed ion exchange resins.

In another aspect of the present invention, smaller diameter anion and/or cation exchange resin beads are used to improve the performance of the mixed bed ion exchange resin layers within the water purifying apparatus. In addition, the present invention is also directed to performing a prewashing and extraction process on an adsorbing material having a low ash content, such as activated carbon formed from pyrolyzed resins to enhance the overall performance of the water purifying apparatus.

In another aspect of the present invention, a free-floating inter-resin layer screen is provided to separate the alternating layers of filtration materials, including activated carbon and mixtures of ion exchange resins within the cartridge housing. The screen also acts as a secondary flow distributor between the carbon and resin layers. The free-floating inter-resin layer screen also prevents shifting and undesired mixing of the alternating layers of filtration materials.

DETAILED DESCRIPTION OF THE INVENTION

The present invention is directed to a method and apparatus for producing high purity water, with very low organic and ionic contamination, having a resistivity of greater than about 17.5 megohm-cm, and TOC levels less than 5 parts per billion.

The present invention utilizes at least one cartridge housing having an inlet and an outlet, and containing one or more sequential layers of activated carbon and mixed bed anion and cation exchange resin. The cartridge housing is filled with the alternating layers by methods known to

those skilled in the art. Typically, a predetermined quantity of a first layer is poured into the cartridge, and the cartridge is shaken to fill any void spaces. This procedure is repeated with alternating layers of material until a final desired level is achieved.

A water feed stream enters the cartridge housing through the inlet, and is removed through the cartridge outlet after it has been treated for use. The purified water outlet stream may also be recycled through the cartridge. The inlet flow of water may be evenly distributed over the sequential layers of activated carbon and mixed bed anion and cation exchange resin, for example, by a flow distributor device as shown and described in co-pending U.S. Patent Application Serial No. 08/598,818, entitled Water Purification Cartridge Assembly with Unidirectional Flow Through Filter Media, filed concurrently herewith on February 9, 1996, and which is incorporated herein by reference.

The number and height of each of the sequential layers of activated carbon and mixed ion exchange resin can vary depending on the requirements of the water to be treated. Although as few as 2 layers can be used in a cartridge, it has been found that between about 4 and 10 layers in a single filter cartridge are most effective in producing high purity water. The total number of layers used in a single filter cartridge is, in part, a function of the overall volume of the cartridge. The thickness of each of the layers is determined by the type of resin and activated carbon and the impurities found therein. Typically, the thickness of each individual layer can range from about 1 percent to about 50 percent of the overall cartridge height. Most preferably, the thickness of each layer is between about 10 and about 40 percent of the overall cartridge height to provide adequate residence time for the water to be treated in each layer. If the layer is too thin, the water will pass through it quickly, and will fail to be treated effectively. Conversely, if the layer is too thick, residual ionic impurities (in the activated carbon layer) and/or organic impurities (in the resin layer) may be released into the water stream. As is known to those skilled in the art, the activated carbon layers typically absorb the organic contaminants present in the feed water and/or released by the resin, and the mixed bed ion exchange resin layers remove the ionic impurities from the feed water and/or released by the carbon.

The ion exchange resins are available in particle sizes ranging between about 200 microns to about 2 mm. In another aspect of the present invention, it has been found that smaller diameter ion exchange resin beads can be used to improve the performance of the mixed bed ion exchange resin layers and, therefore, the overall water purity produced by the present invention. It is believed that the smaller size of the resin beads improves the kinetics of the overall reaction,

in part, by the improved total surface area of the smaller sized resin beads. Along these lines, it has been found that substituting smaller cation resin beads, having a nominal particle diameter of 350 microns, for cation resin beads having a nominal particle diameter of about 590 microns in an alternating configuration similar to those described above, the total capacity utilization of the mixed ion exchange resins was increased. In particular, the total capacity utilization using 40 percent, by volume, of a mixed ion exchange resin layer of the smaller cation resin beads, and using similar feed water conditions, was about 8 percent higher than for the larger size cation resin beads. A 75 percent capacity utilization was realized with the larger cation resin beads, which accounted for about 40 percent of an approximately uniform resin bead size mixture, and 83 percent capacity utilization was realized when the mixture included 40 percent, by volume, of the smaller cation resin beads mixed with larger anion resin beads. Moreover, if the anion bead size is similarly reduced, such that an approximately uniform resin bead size mixture is formed, the total capacity utilization is expected to increase.

Although both types of resin are typically produced as substantially equivalent sized spherical beads, as noted, either the anion or cation resin can have a reduced size relative to the other. Moreover, the resin can be mixed in various proportions to obtain the desired level of removal of ionic contamination from a water stream. The smaller resin bead (either anion or cation resin) can range from between about 40 percent to about 90 percent of the size of the larger bead. Preferably, the smaller resin bead is about 65 percent of the size of the larger bead. The ratio of cation to anion resin can be adjusted between 1:10 to 10:1, depending upon the feed water and the desired level of purity in the water produced. Most preferably, equal parts of cation and anion resin are used in the mixed bed ion exchange resin layers to provide an approximately equal number of sites for ion collection.

Adsorption materials can be used to remove a wide variety of organic, and sometimes inorganic, contaminants. Such materials include natural and synthetic adsorbents including activated carbon, carbonaceous adsorbents such as Ambersorb™ adsorbants, available from Rohm & Haas Company, Philadelphia, PA, and the like. Most typically, the present invention utilizes an activated carbon material that is adsorptive to a wide variety of organic materials and has a low ash content. As is known to those skilled in the art, ash (fines) is formed from the residues of pyrolyzed spherical petroleum distillate or resin beads that are used to produce the carbons. Carbons made by pyrolyzing resin beads, or high molecular weight petroleum distillate residues, are inherently low in ash (fines) content. Furthermore, carbons formed from resin

beads or high molecular weight petroleum distillate residues generally provide a more uniform spherical size than those produced from coal or organic materials. Activated carbons made from coal or organic materials typically include between about 5 and 20 percent ash prior to washing. The substantially uniform size and spherical shape of the carbon particles allows for more efficient handling and packing. The low ash (fines) content minimizes any leaching and channeling within the filter cartridge.

It has been found that a washing and extraction process used with the higher purity activated carbons formed from resin beads, or with low ash/impurity carbonaceous adsorbents, results in even better physical properties and performance of the activated carbon, versus those carbons and adsorbents that are not prewashed. In another aspect of the present invention, therefore, a prewashed, low ash activated carbon can be used to improve the performance of the filtration apparatus resulting in enhanced overall water purity. During the carbon processing, a substantially uniform sized and spherical shaped activated carbon, such as Kureha™ carbon, available from Kureha Chemical Industry Co., Ltd., Japan, is mixed with deionized water (about 17 megohm-cm) at a ratio of about 2:1. The mixture is then heated to a temperature of between about 170°F to about 220°F, and is allowed to stabilize for a predetermined period of time depending upon the quantity of carbon being washed. This period, for example, can last between about 1.0 and about 2.0 hours. The initial deionized water bath is then drained, and fresh deionized water is added to the activated carbon. The conductivity of the drained water is measured, and the procedure is repeated until a desired level is achieved. The initial conductivity of the water decreased from approximately 20 μMhos/cm to below 2 μMhos/cm. After each rinse, the activated carbon is purged with nitrogen for a predetermined period of time to release any gases that may be trapped within the porous carbon. The activated carbon is dewatered (dried) for use in the filter cartridge of the present invention after the final rinse and nitrogen purge.

In another aspect of the present invention, a free-floating inter-resin layer screen is provided to separate the alternating layers of the filtration materials within the cartridge housing. The free-floating inter-resin layer screen prevents shifting and undesired mixing of the alternating layers of filtration materials during use, production, or shipping and handling. As with any internal component of a water purification device, the free-floating inter-resin layer screen may be constructed of any material which substantially limits solvent absorption by the water of contaminants. Typically, the inter-resin layer screen is made from an inert plastic or

metallic material. The screen is preferably made from a low extractable material, such as polyethylene, polypropylene, PVDF, Teflon® resin or another fluorinated thermoplastic material, nylon, and the like.

The screen can also act as a secondary flow distributor between the activated carbon and resin layers. The screen prevents the passage of carbon or resin particles to the alternate adjacent layer while allowing water to pass with a minimal pressure drop. The screen, therefore, acts as a secondary fluid distributor within a filter cartridge housing. Accordingly, the inter-resin layer screen typically includes an open area of between about 5 and about 95 percent, while having a thickness of between about 0.015 inch to about 0.25 inch. As noted, the screen is free-flowing (not rigidly fixed to any surface of the cartridge or any other component of the filtration apparatus) between the filtration particulate layers. Typically, the screen is cut to the cross-sectional shape, and dimensions, of the inside perimeter of the cartridge housing to prevent carbon and/or resin particles from mixing along this surface. To further prevent the layers from mixing, the screen may include a rigid outer rim to provide the screen with added stability. The addition of a rigid outer rim would also operate to prevent fluid channeling along the inner surface of the cartridge by redirecting the fluid flow away from the cartridge housing walls.

The layered filtration media configuration, including the free-floating inter-resin screen separator, of the present invention can, for example, be incorporated in a filtration device as shown and described in co-pending U.S. Patent Application Serial No. 08/598,818, entitled Water Purification Cartridge Assembly with Unidirectional Flow Through Filter Media, filed concurrently herewith on February 9, 1996, and which is incorporated herein by reference.

The present invention will be further illustrated by the following examples, which are intended to be illustrative in nature and are not to be construed as limiting the scope of the invention.

EXAMPLE I

A water purification apparatus, including at least one cartridge housing, having an inlet and an outlet, and at least one layer of activated carbon positioned upstream of at least one layer of mixed ion exchange resin, was prepared and evaluated to determine the effectiveness of the apparatus in providing pure water substantially free of both organic and ionic contaminants.

Pretreated water (by reverse osmosis) having a conductivity of about 5.0 μMhos/cm was pumped at about 2.0 liters per minute through the cartridge. A cylindrical polypropylene cartridge was used having an inner diameter of about 6 inches and was about 12 inches tall. The

cartridge was filled with four alternating layers of activated carbon and mixed bed anion and cation exchange resins. The ion exchange resin used was Monosphere™ MR-3 mixed bed resin having a 1:1 ratio in capacity of anion and cation resin, available from Dow Chemical Company, Midland, MI. The activated carbon used was Kureha™ carbon in bead form (substantially spherical particles) having a very low ash content of less than 0.5 percent, by weight.

The cartridge was filled with four layers of various thickness (relative to the overall cartridge length). No screen separation device was inserted between the alternating layers. Proceeding downstream, as contacted by the feed water, the layers included activated carbon (12 percent), a mixed anion and cation exchange resin bed (58 percent), activated carbon (12 percent), and a mixed ion exchange resin bed (18 percent). The product water resistivity was measured at the cartridge outlet to be greater than 17.6 megohm-cm, and total organic content (TOC) levels in the product were found to be less than 5 parts per billion.

EXAMPLE II

The cartridge of EXAMPLE I was filled with four alternating layers of the activated carbon and mixed ion exchange resins (as described in EXAMPLE I) having approximately equal thickness (each layer was 25 percent of the cartridge length), beginning with activated carbon and ending with the mixed ion exchange resin bed. A free-floating inter-resin layer screen was inserted between each alternating layer. The activated carbon had a very low ash content and was prepared by a separate washing and extraction process prior to filling the cartridge. The water fed to the cartridge was pretreated similar to that used in EXAMPLE I (reverse osmosis), and it was also fed through a layer of activated carbon and a layer of mixed ion exchange resin prior to its passage through the four-layered cartridge. The water was pumped at about 2.0 liters per minute through the cartridge. The product water resistivity was measured at the cartridge outlet to be greater than 17.6 megohm-cm, and the TOC levels were found to be less than 5 parts per billion.

EXAMPLES I and II illustrate that multiple layers of activated carbon and mixed ion exchange resin in a cartridge can be effectively used to purify water and substantially remove all organic and ionic impurities. Moreover, the EXAMPLES I and II show that the carbon and resin layers can each vary in thickness within the cartridge while still providing water that is substantially free of organic and ionic contaminants.

EXAMPLE III

The cartridge of EXAMPLE I was filled with six alternating layers of the activated carbon and mixed ion exchange resins. The order of the layers included carbon (8.3 percent), mixed bed ion exchange resins (58.3 percent), mixed bed ion exchange resin (8.3 percent), carbon (8.3 percent), and mixed bed ion exchange resin (8.3 percent). Similar to EXAMPLES I and II, the water fed through the cartridge was reverse osmosis pretreated water, at a flow rate of 2 liters per minute. The product water resistivity was measured at the cartridge outlet to be no greater than 13.0 megohm-cm.

This EXAMPLE indicates that the layering order and thicknesses of the filtration media have a significant effect on the purity of the water produced.

EXAMPLE IV

To determine the effectiveness of the above-described prewashing and extraction process on activated carbon, the cartridge of EXAMPLE I was filled with four alternating layers of the activated carbon and mixed ion exchange resins (as described in EXAMPLE I) having approximately equal thickness (each layer was 25 percent of the cartridge length), beginning with activated carbon and ending with the mixed ion exchange resin bed. The carbon used was only rinsed with a reverse osmosis treated water at room temperature for about an hour. The carbon, therefore, was not subjected to the prewashing and extraction process described above and as used on the carbons used in EXAMPLES I, II and III. The resin used was a very low total organic content, uniform bead size mixed bed. As with all other EXAMPLES, the water fed through the cartridge was reverse osmosis pretreated water and, as in EXAMPLE II, it was also fed through a layer activated carbon and a layer of mixed ion exchange resin prior to its passage through the four-layered cartridge. The product water resistivity was measured at the cartridge outlet and never reached 17.5 megohm-cm.

The same rinsed carbon was used in a cartridge having six alternating layers having approximately equal thicknesses (each layer was about 17 percent of the cartridge length), beginning with activated carbon and ending with mixed bed ion exchange resin. The cartridge was fed with similarly pretreated water, and the product water resistivity never reached 15.0 megohm-cm.

EXAMPLE IV illustrates the effectiveness of the present invention's prewashing and extraction processing on an adsorption material such as activated carbon prior to its use in a water filtration cartridge including alternating layers of carbon and mixed ion exchange resins.

Although particular embodiments of the invention have been described in detail for purposes of illustration, various modifications may be made without departing from the spirit and scope of the invention. Accordingly, the invention is not to be limited except as by the appended claims.

CLAIMS

1. A method for purifying water, comprising:

providing a cartridge having an inlet and an outlet;

filling said cartridge with at least one layer of an activated carbon and at least one layer of a mixture of ion exchange resins;

wherein said layers of activated carbon and mixture of ion exchange resins are separated by a free-floating inter-resin layer screen;

passing a water stream into said cartridge inlet and through said separated layers of activated carbon and mixed ion exchange resins to produce a pure water stream substantially free of organic and ionic contaminants; and

removing said purified water from said cartridge outlet.

2. The method of claim 1, wherein said purified water has a resistivity of greater than 17.5 megohm-cm and a TOC level of less than 5 ppb.

3. The method of claim 1, wherein said cartridge is filled with between about 2 and 10 alternating layers of said activated carbon and said mixture of ion exchange resins.

4. The method of claim 3, wherein said layers each have a thickness of between about 1 and about 50 percent of the overall height of said cartridge.

5. The method of claim 4, wherein said layers each have a thickness of between about 10 and about 40 percent of the overall height of said cartridge.

6. The method of claim 1, wherein said mixture of ion exchange resins comprises anion exchange resins and cation exchange resins in a ratio of between about 1:10 to about 10:1.

7. The method of claim 1, wherein said ion exchange resin beads are substantially spherical and have a nominal particle size of between about 200 microns and about 2 mm.

8. The method of claim 6, wherein said ion exchange resins include substantially equal parts of anion and cation exchange resins.

9. The method of claim 6, wherein one of said anion and cation exchange resins has a nominal particle size that is between about 40 percent to about 90 percent of the nominal particle size of the other exchange resin.

10. The method of claim 9, wherein one of said anion and cation exchange resins has a nominal particle size that is about 65 percent of the nominal particle size of the other exchange resin.

11. The method of claim 1, wherein said activated carbon is prewashed and is formed from pyrolyzed resin.

12. An apparatus for purifying water, comprising:

at least one cartridge housing having an inlet and an outlet;

at least one layer of an activated carbon bed and at least one layer of a mixture of ion exchange resins;

wherein said layers of activated carbon and mixture of ion exchange resins are positioned within said cartridge housing; and

a free-floating inter-resin layer screen positioned between said layers of activated carbon and mixture of ion exchange resins.

13. The apparatus of claim 12, wherein said cartridge is filled with between about 2 and 10 alternating layers of said activated carbon and said mixture of ion exchange resins.

14. The apparatus of claim 13, wherein said layers each have a thickness of between about 1 and about 50 percent of the overall height of said cartridge.

15. The apparatus of claim 14, wherein said layers each have a thickness of between about 10 and about 40 percent of the overall height of said cartridge.

16. The apparatus of claim 12, wherein said mixture of ion exchange resins comprises anion exchange resins and cation exchange resins in a ratio of between about 1:10 to about 10:1.

17. The apparatus of claim 12, wherein said ion exchange resin beads are substantially spherical and have a nominal particle size of between about 200 microns and about 2 mm.

18. The apparatus of claim 16, wherein said ion exchange resins include substantially equal parts of anion and cation exchange resins.

19. The apparatus of claim 16, wherein one of said anion and cation exchange resins has a nominal particle size that is between about 40 percent to about 90 percent of the nominal particle size of the other exchange resin.

20. The apparatus of claim 19, wherein one of said anion and cation exchange resins has a nominal particle size that is about 65 percent of the nominal particle size of the other exchange resin.

21. The apparatus of claim 12, wherein activated carbon is prewashed and is formed from pyrolyzed resin.

22. The apparatus of claim 12, wherein said free-floating inter-resin layer screen is constructed of an inert material, has an open area of between about 5 and about 95 percent, and has a thickness of between about 0.015 inch to about 0.25 inch.

23. The apparatus of claim 22, wherein said screen further includes a rigid outer perimeter rim.

24. A method for purifying water, comprising:

providing a cartridge having an inlet and an outlet;

filling said cartridge with at least one layer of an activated carbon and at least one layer of a mixture of ion exchange resins;

wherein said mixture of ion exchange resins comprises anion exchange resins and cation exchange resins in a ratio of between about 1:10 to about 10:1, and one of said resins has a nominal particle size that is between about 40 percent to about 90 percent of the nominal particle size of the other resin;

passing a water stream into said cartridge inlet and through said layers of activated carbon and mixed ion exchange resins to produce a pure water stream having a resistivity of greater than 17.5 megohm-cm and a TOC level of less than 5 ppb; and

removing said purified water from said cartridge outlet.

25. A method for purifying water, comprising:

providing a cartridge having an inlet and an outlet;

washing an activated carbon material in water at a temperature of between about 170°F to about 220°F;

filling said cartridge with at least one layer of said prewashed activated carbon and at least one layer of a mixture of ion exchange resins;

passing a water stream into said cartridge inlet and through said layers of activated carbon and mixed ion exchange resins to produce a pure water stream having a resistivity of greater than 17.5 megohm-cm and a TOC level of less than 5 ppb; and

removing said purified water from said cartridge outlet.

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 97/01721

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 C02F1/28 C02F1/42 C02F1/00 B01J47/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 C02F B01J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 368 123 A (STANLEY) 11 January 1983	1,3,4,6, 8,12-14, 16,18
Y	see column 2, line 28 - line 39; figure 1	2,5,7,9, 15,17,19
	see column 3, line 6 - line 48; figure 2 ---	
Y	US 4 876 014 A (MALSON) 24 October 1989	2,7,17
A	see column 1, line 7 - line 20 see column 3, line 25 - line 33 see column 4, line 59 - column 5, line 5 see column 6, line 34 - column 8, line 32 see figures 3-5 ---	24,25
Y	US 4 287 057 A (STANLEY) 1 September 1981 see figure 2	5,15
A	see column 2, line 47 - column 3, line 45 --- -/--	1,3-5, 12-15,23

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
26 May 1997	04.06.97

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Ruppert, G

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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